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**EURO-CITI Tele-Voting: An Application for Realizing  
Opinion Poll Petitions**

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## Abstract

*In this paper, the EURO-CITI tele-voting application is presented. This application enables local authorities to initiate a call-for-vote on a local problem, to set-up networks of local authorities' servers and initiate a call-for-vote on common problems, to monitor voting results and extract statistical information, etc. It further enables citizens to vote on local or common problems using PC, kiosks or WAP-enabled devices, to view voting results on their area or other areas (in the case of common voting), to propose their own call-for-vote, etc. The work reported in this paper includes an evaluation of tele-voting for realizing opinion poll petitions and a presentation of EURO-CITI tele-voting system user requirements, technical architecture and design. The tele-voting application is currently deployed and will be evaluated in three European cities, namely Athens, Barcelona and London borough of Brent.*

**Keywords:** *tele-voting, EURO-CITI, opinion poll petitions, e-democracy, local authorities.*

## 1. Introduction

Tele-voting systems have attracted significant research interest over the past few years. Particularly important is Internet voting, i.e. tele-voting over the Internet. In this study, the term tele-voting will refer to Internet voting. The scientific effort around tele-voting has been lately coupled with an increasing commercial interest. This is particularly true in the United States of America after the last presidential elections and the problems encountered with current voting methods. The member states of the European Union have also started to consider the potential of tele-voting. For example, a large number of tele-voting systems will be deployed and tested during the elections in UK local authorities on the 2<sup>nd</sup> of May 2002. Currently, tele-voting is the main focus of many projects [1-3], services provided by companies [4-7], Internet portals and mailing lists [8]. A comprehensive survey on tele-voting including relevant bibliography is presented in [9]. However, despite the general enthusiasm there is still considerable skepticism with regards to the use of tele-voting systems in official elections. This skepticism includes technological as well as social aspects.

The focus of this paper is on the use of tele-voting for realizing opinion poll petitions in European cities. More specifically, a tele-voting application is presented, which is currently deployed in three cities in order to conduct local as well as networked opinion polls on common issues. User requirements analysis revealed that the characteristics of tele-voting applications for realizing credible opinion poll petitions are comparable, although less demanding in terms of security, to that of tele-voting applications for elections. Furthermore, the use of simple Web forms that can be filled in anonymously are not sufficient for credible opinion poll

petitions, such as those carried out by cities. Based on these requirements, the EURO-CITI tele-voting specifications were derived and the application was developed. It should be noted that the work presented in this paper was carried out within the EURO-CITI project [10] [11].

The rest of this paper is organized as follows. In Sections 2 and 3 the advantages, drawbacks and requirements of tele-voting systems for elections are presented. In Section 4, tele-voting systems for elections are compared with tele-voting systems for realizing opinion poll petitions. In Section 5 an abstract description of the EURO-CITI tele-voting application is given while in section 6 the user requirements are presented. In Section 7 the technical architecture is outlined and in section 8 the component diagram is depicted. In Section 9 the steps towards system evaluation are outlined. Finally, in Section 10 the main conclusions are given.

## **2. Tele-Voting for Elections: Advantages and Drawbacks**

The main arguments in favor of tele-voting include [12]:

- **Participation:** It is expected that participation in the voting process will increase, particularly between the young ages. The problem of small participation in elections is becoming a significant one. For example, in 1998 the turnout rate for the general election in the United States was only 44.9 percent, while only 15 percent of people between the ages of 18 and 24 voted.
- **Convenience:** This is probably the most compelling argument in favor of tele-voting. Convenience encourages participation, which should lead to a stronger electorate.
- **Access:** Increased access is expected to leverage participation especially in certain groups such as the handicapped, people living abroad and frequent travelers.
- **Knowledge:** Tele-voting may revolutionize the way that campaigns are financed and run. Furthermore, tele-voting allows officially approved information on each candidate to be readily available to the voters even while they are actually in the voting booth.
- **Efficiency, streamlining and consolidation of the voting process:** Tele-voting may be the quickest, cheapest, and most efficient way to administer elections and count votes. These systems would free up geographic location as an absolute requirement for where people vote.

On the other hand, the main arguments against tele-voting include:

- **Security:** Tele-voting is vulnerable to a variety of hacker created problems (viruses, Trojan horses etc.). Other security problems are: insuring the privacy

of voter; authentication and verification of the voter; and collecting and counting the votes.

- **Digital divide:** There are two groups that might be left behind by the adoption of tele-voting: communities (including nations) with little penetration of technology, and individual voters without access to Internet connections.
- **Civic Disillusionment/Cheapening of the Vote:** The introduction of tele-voting could make elections less of a community event, which might create a greater gap between citizens and government, thereby decreasing participation and transform voting, an inherently public activity, into a private one.
- **Distrust:** Many people believe that managers of tele-voting systems would have the potential to significantly influence public elections if strong precautions are not taken.

### **3. Tele-Voting for Elections: Requirements**

An electronic voting system may be divided into three phases [13]:

- Registration phase.
- Voting phase.
- Tallying phase.

In order to overcome as many drawbacks as possible, tele-voting systems for elections must fulfill the following requirements [13]:

- 1 **Convenience:** A voting system is convenient if it allows voters to cast their ballots quickly, in one session and with minimal equipment or special skills.
- 2 **Flexibility:** A voting system is flexible if it allows voters to ask a variety of ballot-related questions in various formats including open-ended questions.
- 3 **Mobility:** A voting system is mobile if there are no restrictions on the location from which a voter can cast a ballot, other than those imposed by the limits of the network's perimeter.
- 4 **Scalability:** A voting system is scalable if it allows an indefinite number of voters to participate in the election.
- 5 **Security:** This is the most important requirement and includes four others:
  - 5.1 **Accuracy:** A voting system is accurate if (a) it is not possible for a validated ballot to be altered, (b) it is not possible for a validated ballot to be eliminated from the final tally, and (c) it is not possible for an invalid ballot to be counted in the final tally.

- 5.2 Democracy: A voting system is democratic if only eligible voters can vote and each of them can vote only once.
- 5.3 Privacy: This is subdivided in:
  - a. Anonymity: Neither the voting authorities nor anyone else can link any ballot to the voter who has cast it.
  - b. Non-coercibility: No voter can prove that he voted in a particular way.
  - c. Fairness: All ballots remain secret during the voting phase.
- 5.4 Verifiability: There are two categories of verifiability, namely universal verifiability and individual verifiability. A voting system is universally verifiable if anyone can independently verify that all ballots have been counted correctly. A voting scheme is individually verifiable if voters can independently verify that their own ballots have been counted correctly.

It should be noted that some of these requirements are contradictory to each other, e.g. anonymity and individual verifiability.

#### **4. Tele-Voting for Elections and For Opinion Poll Petitions**

Tele-voting systems for realizing opinion poll petitions should also fulfill the requirements listed in the previous section. Therefore, most of the existing opinion poll petitions systems, which are based on Web forms, are not appropriate since they fail one or more of these requirements. For example, Web forms do not often involve any authentication mechanism hence fail the requirement of democracy.

However, opinion poll petitions are considered as less strict in terms of the security requirement. This relaxation is derived from the fact that the voting authorities (in this case the cities) may be considered as trusted entities. Therefore, tele-voting systems for realizing opinion poll petitions may not include audit mechanisms as well as mechanisms to prevent inside fraud and sabotage.

Furthermore, the tele-voting applications for opinion poll petitions will be administrated by non-technical experts. It is therefore evident that an equally important requirement for that system is manageability. The term “manageability” can be defined as follows:

- 6. Manageability: A voting scheme is manageable if it can be administrated in an intuitive, user-friendly manner. Administration tasks include initialization, configuration, deployment and termination of multiple tele-voting services.

This requirement is particularly important in the case of tele-voting systems that will be used multiple times as in the case of systems for realizing opinion poll petitions. It should be expected that these systems would be administrated by

personnel without technical skills. For example, typical administrators of the foreseen tele-voting application are expected to be secretaries in a local authority. This requirement is similar to the concept of sustainability as presented in [14].

## 5. EURO-CITI Tele-Voting: Tools and Scenarios

The EURO-CITI tele-voting application consists of two different tools:

- The Tele-voting Administrative Tool.
- The Tele-voting Service for the Citizens.

The EURO-CITI tele-voting service will be used for realizing opinion poll petitions. More specifically, the participating local authorities identified three tele-voting scenarios as particularly important:

- **“Local Voting”**. In this case, a voting issue is posted in one EURO-CITI server and eligible voters are citizens who are registered in that server.
- **“Local Voting with European Scope”**. In this case, a voting issue is posted in one EURO-CITI server (termed *initiator*). Here, eligible voters consist of citizens who are registered in the initiator as well as citizens from other cities. These cities however must have been invited by the initiator and accepted that invitation.
- **“Network Voting”**. In this case, a voting issue is proposed by one EURO-CITI server (termed *initiator*) and is posted in all servers (i.e. cities) that have accepted to participate in that voting. Here, eligible voters for each server are the citizens who are registered in that server.

## 6. EURO-CITI Tele-Voting: User Requirements

The user requirements of the EURO-CITI tele-voting application were gathered using the method of questionnaires. The questionnaires were filled in by representatives of the participating local authorities, i.e. Barcelona, Brent and Athens. In all cases, the questionnaires were handled by experienced personnel at local authorities who are also responsible for public services. In some cases, discussions with citizens’ representatives were also conducted. As a result, it is expected that these requirements are applicable to any tele-voting application for realizing opinion poll petition in cities or other distributed organizations such as unions, universities etc.

## **6.1 Roles and Actors**

Based on the user requirements five actors were identified. These actors are:

- Guest user: A person that visits the web site of the services but does not possess a username and password or a smart card.
- Registered user: A citizen that has obtained a username and password or a smart card.
- Tele-voting operator: The administrator of the tele-voting services.
- Operator manager: A person that manages the complete system, that is, the assignment of different operators, the control of system logs, archives...
- Registration operator: A person in charge of managing the registration of users.

## **6.2 General Requirements**

The general requirements are:

- The service should be widely available and easily accessible.
- The service should be easy to use and require no particular skills.
- Citizens should be able to access the service either as registered or guest users.
- Citizens must be able to become registered users.
- Citizens should be able to make some personal preferences concerning the language, issues of interest and personal profile

## **6.3 Operators Requirements**

The operators' requirements are:

- The system should support a large number of users.
- The system should be operated in a friendly manner and without any special technical skills.
- The management of the services should be made by more than one operator in a way that will enhance security and will help in grouping and making tasks of operators distinct.
- The operator must be able manage the services in his preferred language.
- The system must provide some form of back up (archive) where every data will be stored in order to prevent data loss.
- The system must incorporate auditing facilities.



## **6.4 Citizens Requirements**

The requirements of the guest user are:

- The non-registered users should be able to access the service and view general information

The requirements of the registered user are:

- The service should cover a wide range of voting issues and topics.
- Voting must be secure and anonymous.
- The system should be based upon democratic procedures, i.e. no one should be allowed to vote more than once for the same issue and no one should be able to alter votes
- Users should be able to verify their personal voting.
- The user should be notified about forthcoming polls.
- The user should be able to view the results of previous voting issues.
- The user may be able to view the partial results of current voting issues.
- The user should be able to suggest a voting issue.

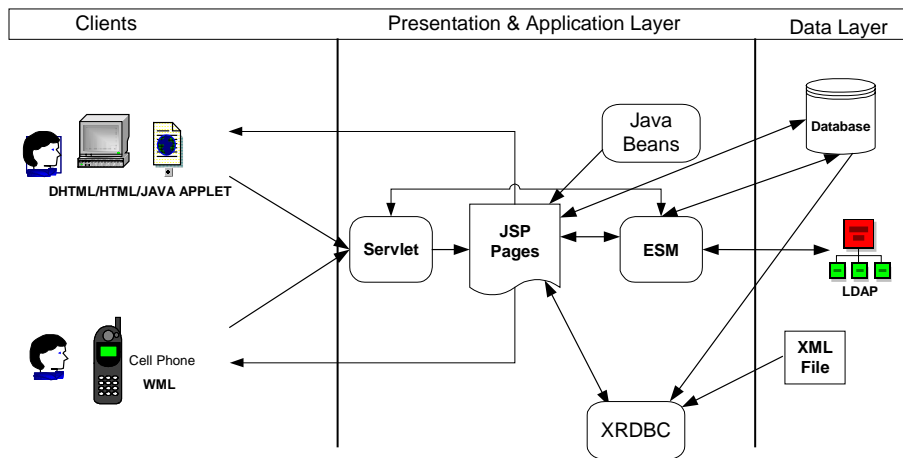
## **7. Technical Architecture**

The architecture used to design the whole EURO-CITI platform is based on the J2EE standard, thus fulfilling the project's commitment to invest on standards and open architectures through the support of a consistent and stable architecture, which can be easily enhanced and maintained.

The design of both tele-voting administrative tool and services is layered according to the model-view-controller approach, thus distinguishing the presentation, the application and the data layers.

Moreover, the design of tele-voting administrative tool and services provides an efficient way to handle the presentation issues, even covering the access from multiple devices in the case of the citizen. Towards this, the EURO-CITI platform is developed to produce dynamic content in order for all the supported user clients to be able to digest it. This special characteristic of the EURO-CITI platform must be emphasized, because of its decisive role for the selection of the implementation technologies as well as the deployment ones.

The selected architecture combines several Java as well as XML technologies as depicted in the figure 1.



*Figure 1: EURO-CITI Tele-Voting Architecture*

The initiation of user interaction is performed through a controller **Servlet** from which the user's device and language is detected and subsequently the application execution is directed to the relevant JSP page.

**JSP pages** incorporate the application as well as the presentation logic of the tele-voting system. Most of the application logic and database update/delete/insert operations are performed directly through these pages. However, the activities towards the presentation of information are processed through the XRDBC component, whereas a part of the application logic is executed inside the **Java Beans**.

The **XRDBC** component is utilized as the data gateway and transformation engine for tele-voting applications. Towards this, several XRDBC templates (XML files) are implemented to determine the required information and the processing rules for this information. XRDBC is a tool for bridging the gap between XML and relational databases, while overcoming the weaknesses and constraints of various database management systems. XRDBC heavily depends on JDBC and JAXP in order to achieve this goal. It provides two core facilities:

- XML composition i.e. the population of a given XML structure with data retrieved from a relational database. In this regard XRDBC can be thought of as an XSLT processor that operates on a rowset instead of an infoset.
- XML decomposition (aka shredding) i.e. transformation of an XML structure to sets of relational tuples.

The most interesting features of XRDBC include:

- Dynamic creation and configuration of database connections using either JDBC driver managers or data source instances stored in JNDI service providers. Binding of JDBC drivers is dynamic in both cases.

- Multiple concurrent connections for updating and querying using either SQL statements or stored procedures. XRDBC uses prepared statements in both cases.
- Built-in library of functions for processing Java objects: It provides string processing and formatting, event processing and condition evaluation.
- Formal parameter and runtime argument manipulation.
- Thread-safe and reentrant API.

In brief, XRDBC operates in the following manner: Before any interaction with the DBMS takes place, a new session must be created. The XRDBC session processor reads a script (XRDBC template) and prepares all required interactions with the DBMS. This script's document type definition caters for a number of elements and attributes for making the required interactions with a DBMS, specifying formal parameters and expressions and serializing/decomposing the retrieved/incoming data. Once a session is created, it can be executed i.e. used for composing or shredding. In the case of XML document composition, which is the most popular, XRDBC employs a rowset reader that scrolls through relational data and fires events when the rowset is opened or closed, a row of data is available, and when a group of rows begins on a specific column. These events are consumed by a serializer, which visits the object model and according to its structure generates XML data.

Although XRDBC can be extended for handling record update/insert/delete, in terms of EURO-CITI the data retrieval is considered as its basic application.

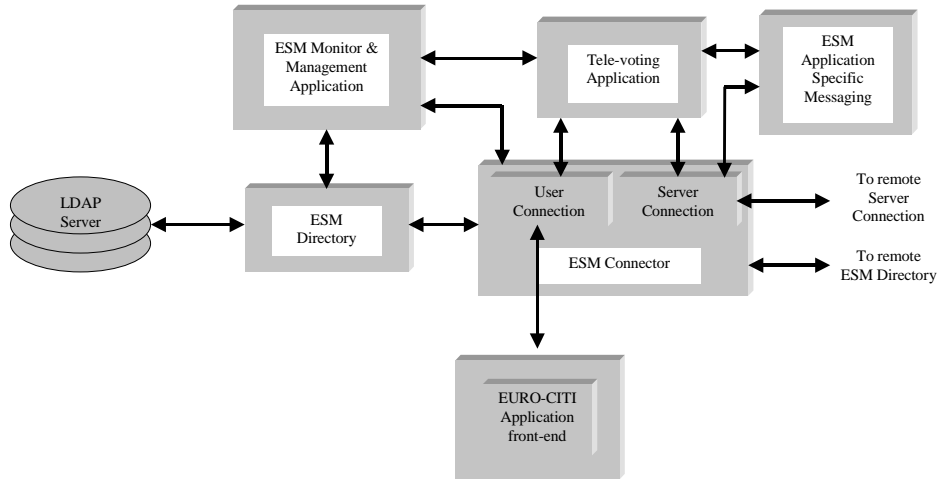
With respect to authentication/authorization, the **EURO-CITI Security Manager** (ESM) is contacted to search for the user details against the EURO-CITI LDAP repository. Security issues are addressed through the use of the following identification mechanisms: login/password, digital certificates and smart cards. From the technological viewpoint, secure HTTP provides the application security means, whereas the IPSec protocol is used to establish secured connections between EURO-CITI servers. Secure access to the tele-voting applications implies that:

- Authorized users should be able to access the application from different points of access.
- Unauthorized users should not be allowed to access the application.
- Security requirements for each connection are dependent upon the invoked application.
- Management of users, applications and other entities should only be performed from authorized users.
- Long - term objects that survive through multiple sessions, such as user ids, should be persistent.

ESM provides a simple, yet powerful interface to the EURO-CITI tele-voting application. The design rule is to have simple and straightforward ways to do

simple operations and provide additional functions for managing more complex operations.

The internal structure of the EURO-CITI Security Manager is shown in figure 2. It is only the directory entries that are specific to ESM that are handled by the ESMDirectory module, and it is only through this module the entries can be accessed. This sharing would of course require careful assignment of access rights to the directory so as to prevent leakage of information. The same applies if ESMDirectory interfaces to an RDBMS instead of an LDAP server.



*Figure 2: ESM Architecture*

Tele-voting database conceptual design does not interlink users to their votes, thus preserving user anonymity, which is an important requirement when coping with tele-voting systems. Database entities are protected against unauthorized access whereas integrity constraints ensure that valid operations do not result in a loss of data consistency. Referential integrity is implemented through foreign keys, while indexing accelerates database search. Security rules are applied for each database entity separately, through the definition of access levels for database users.

Database is structured in a vendor-independent manner with respect to the different data repositories that hold tele-voting records at each system's installation. For this reason, database-specific operations (e.g. stored procedures, triggers) are avoided. On the other hand, specific database schemas for SQL Server and Oracle RDBMS are applied.

Database connectivity to the tele-voting applications is performed by means of prepared SQL statements. In several cases, system's robustness is enforced through using SQL transactions.

## 8. Tele-Voting Applications Design

From a more detailed point of view, the relationships between low-level Tele-Voting components as well as the mapping from design view to components (implementation view) are depicted in the following diagram. Please note that in order to avoid redundancy, some components of the televoting administrative tool that are similar to the televoting citizen application ones, are not repeated.

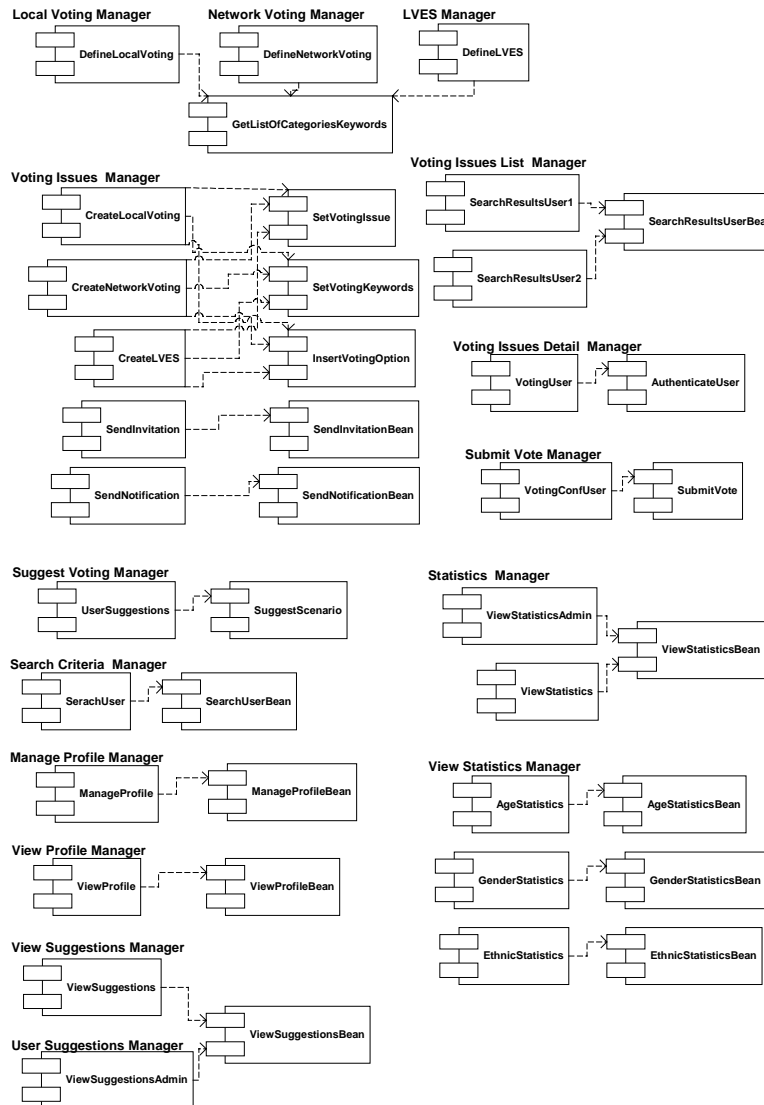
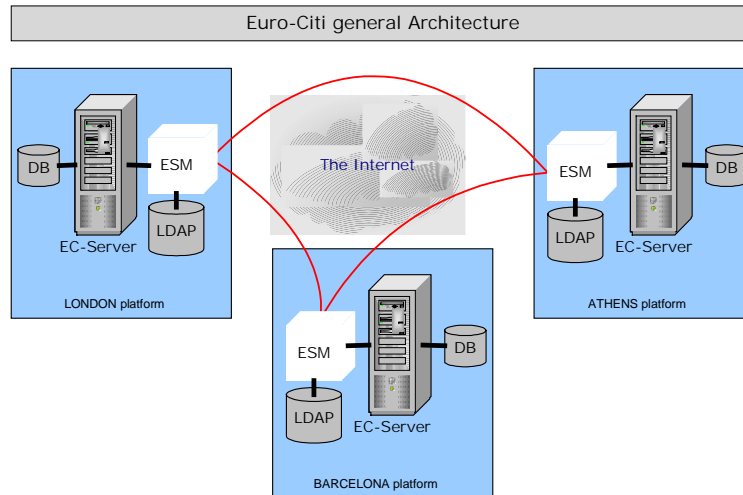


Figure 3: Tele-Voting Component Diagram

## 9. Deployment and Evaluation

The EURO-CITI tele-voting system is currently deployed in Barcelona, Athens and the London borough of Brent (figure 4).



*Figure 4: Deployment of EURO-CITI*

The deployment phase will be followed by a four months evaluation period. During that period a number of citizens (around one hundred per city) will be provided with smart cards while some more will be provided with login/password credentials. Administrators at these cities will launch a series of tele-voting scenarios, including local voting, local voting with European scope and network voting. The trials aim to evaluate the acceptance of tele-voting in general and the EURO-CITI system in particular. For that purpose, the method of questionnaires will be utilized.

## 10. Conclusions

Tele-voting and particularly internet-voting systems have the potential to revolutionize the election process. The advantages of tele-voting include increased participation, convenience and access. At the same time however there is considerable skepticism around technological (e.g. security) and societal (e.g. digital divide) aspects. As a result, it seems that the full adoption of tele-voting is not foreseen in the near future.

An important application domain of tele-voting systems is opinion poll petitions. The use of tele-voting particularly in local communities may reinforce the concept

of direct democracy by allowing citizens to vote on their local problems. The main difference between tele-voting systems for elections and those for opinion polls is security: tele-voting systems for elections have severe security requirements both from external but also from internal attacks. On the other hand, tele-voting systems for opinion poll petitions relax some of these requirements. For example, local authorities are considered as trusted entities thus no auditing mechanisms are necessary. As a result, tele-voting systems for elections are only provided by companies as services that are run from a protected area that can resist both electronic and physical attacks. On the contrary, tele-voting systems for opinion polls can be installed as products at the premises of local authorities. This difference also imposes an additional requirement to the later systems: that of manageability. Indeed, as the systems will be used by non-experts they need to be user-friendly and easy to administrate.

The EURO-CITI system is a proposed tele-voting application to be used by local authorities in order to realize opinion poll petitions. The EURO-CITI tele-voting system allows administrators to initiate a call-for-vote and to select the electoral body based on a number of characteristics (age, sex etc.) It further allows administrators from different cities to initiate simultaneous votings on the same issue. The system enables citizens to vote, to view statistical results, to propose new voting issues etc. Particularly important aspects of the application are authentication/authorisation (performed by both smart cards and login/password), security (between citizens and cities but also between cities) and access (via Web and also WAP-enabled devices). Finally, the development of the application combines a modular architecture by separating the presentation and business logic as well as its data storage layer thus providing scalability, extensibility and maintainability.

Concluding, the EURO-CITI tele-voting application can be considered as a step ahead of trivial online polling applications and behind of tele-voting systems that can guarantee safe and fair online elections. In that respect, it is intended for realizing trustworthy opinion polls by conforming at a good degree to the security requirements for tele-voting systems and by providing high support to the implementation ones. The EURO-CITI tele-voting application can also be considered as an intermediate step on the way to realising electronic elections. This approach will help in preparing gradually the public for the future and in researching-experimenting with all the required technologies.

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